MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2021/2022

EPM2036 –CONTROL THEORY

(TE / RE)

11 AUGUST 2022
9.00 a.m. - 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 5 pages excluding the cover page with 4 Questions only.

2. Attempt **ALL THE FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

a) Draw block diagram of a physical system (Turntable) as shown in Fig. Q1 (a). [8 marks]

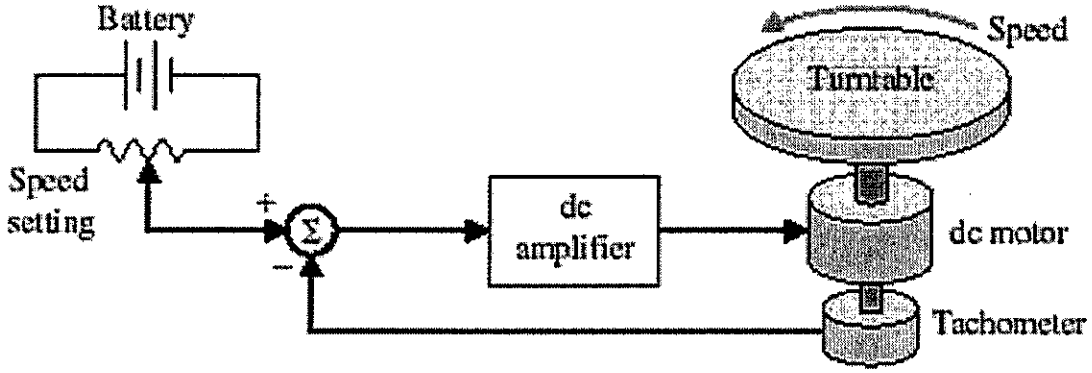

Fig. Q1 (a)

b) Find inverse Laplace transform of $F(s) = \dfrac{5s}{s\ (s+1)(s+2)}$ [5 marks]

c) Simplify the system shown in Fig. Q1(c) to a single block transfer function using block diagram reduction method. [12 marks]

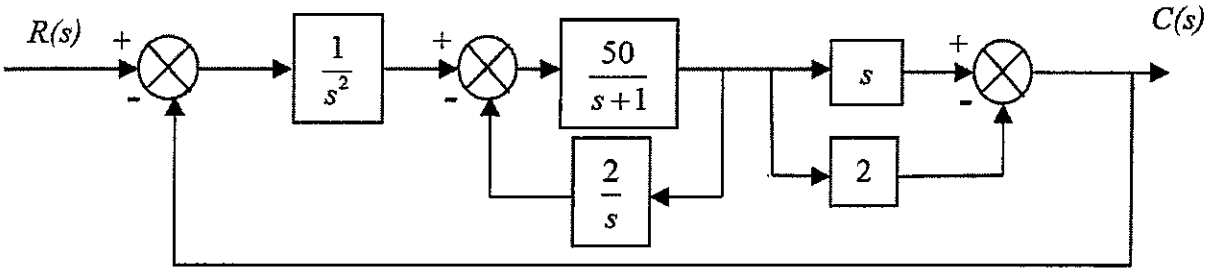

Fig. Q1 (c)

Continued ...

Question 2

a) Construct the signal flow graph (SFG) for the block diagram shown in Fig. Q2 (a) and obtain the transfer function $\frac{C(s)}{R(s)}$ using Block Reduction Techniques.

[3+12 marks]

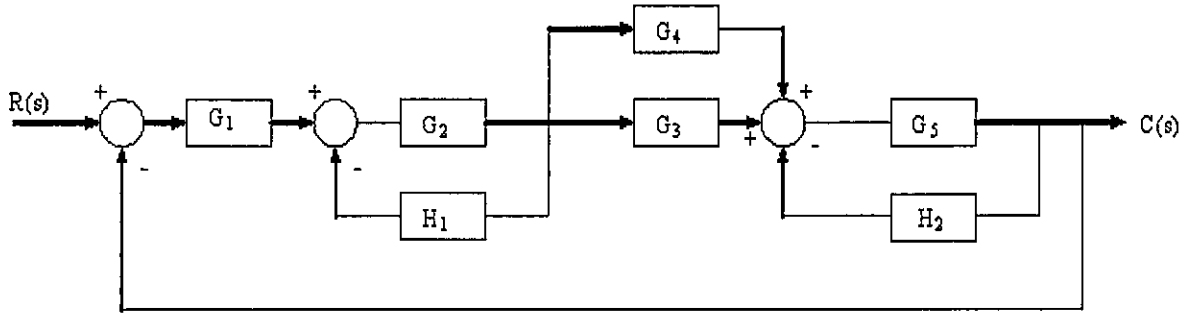

Fig. Q2 (a)

b) The open loop transfer function of a unity feedback system is

$$G(s) = \frac{1}{2s^4 + 6s^3 + s^2 + 2s}$$

Using Routh – Hurwitz criteria,

(i) Determine the stability of the system. [8 marks]

(ii) Find how many roots are lying on the left hand side and right hand side of the s-plane. [2 marks]

Continued ...

Question 3

a) Explain the term "Root Locus" and define the engineer's purpose of study "Root Locus". [1 + 1 marks]

b) What are the purposes of the "Magnitude Criterion and "Angle Criterion" in Root Locus?

[1 + 1 marks]

c) Given a characteristic equation of a control system is:

$$s^4 + 9s^3 + 43s^2 + (143 + B)s + 204 + 2B = 0$$

(i) Tabulate the Routh table for the control system. [10 marks]

(ii) Determine the conditional value of B for the system to maintain stability. [4 marks]

(iii)Determine the root loci points that intersect the imaginary axis. [3 marks]

d) Calculate the FOUR (4) basic factors for the preparation of Bode plot for the following transfer function:

$$G(s) = \frac{5}{s(1+s)(1+0.1s)}$$

[4 marks]

Continued ...

Question 4

a) The open loop transfer function of a unity feedback system is

$$G(s) = \frac{10}{s(s+3)(s+4)}$$

(i) Sketch the Nyquist plot. [8 marks]

(ii) Evaluate the gain margin using the Nyquist Criterion. [2 marks]

b) The feedback system shown in Fig. Q4 (b) below has a plant transfer function G(s) and a PI controller K(s) given by:

$$G(s) = \frac{1}{(s+1)(s+2)} \; ; \; K(s) = K_P + \frac{K_I}{s}$$

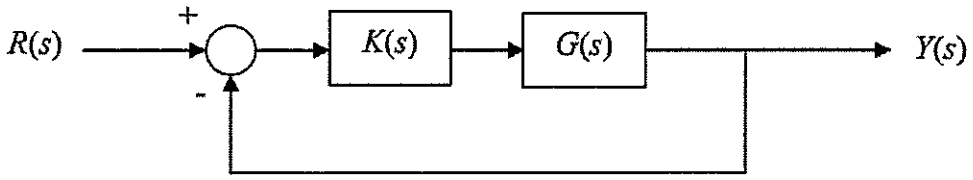

Fig. Q4 (b)

Design the PI controller so that the following specifications are met:

- For a unit ramp input, the steady-state error is no more than 0.02.
- The system is stable (or on the boundary of stability).

Determine the critical values for the proportional and integral gains. Using these critical gains, find the closed-loop transfer function of the system.

[15 marks]

Continued ...

Table of Laplace Transforms

	$f(t)=\mathcal{L}^{-1}\{F(s)\}$	$F(s)=\mathcal{L}\{f(t)\}$		$f(t)=\mathcal{L}^{-1}\{F(s)\}$	$F(s)=\mathcal{L}\{f(t)\}$
1.	1	$\frac{1}{s}$	2.	e^{at}	$\frac{1}{s-a}$
3.	$t^n,\ \ n=1,2,3,\ldots$	$\frac{n!}{s^{n+1}}$	4.	$t^p, p>-1$	$\frac{\Gamma(p+1)}{s^{p+1}}$
5.	$\sqrt{t}$	$\frac{\sqrt{\pi}}{2s^{\frac{3}{2}}}$	6.	$t^{n-\frac{1}{2}},\ \ n=1,2,3,\ldots$	$\frac{1\cdot3\cdot5\cdots(2n-1)\sqrt{\pi}}{2^n s^{n+\frac{1}{2}}}$
7.	$\sin(at)$	$\frac{a}{s^2+a^2}$	8.	$\cos(at)$	$\frac{s}{s^2+a^2}$
9.	$t\sin(at)$	$\frac{2as}{(s^2+a^2)^2}$	10.	$t\cos(at)$	$\frac{s^2-a^2}{(s^2+a^2)^2}$
11.	$\sin(at)-at\cos(at)$	$\frac{2a^3}{(s^2+a^2)^2}$	12.	$\sin(at)+at\cos(at)$	$\frac{2as^2}{(s^2+a^2)^2}$
13.	$\cos(at)-at\sin(at)$	$\frac{s(s^2-a^2)}{(s^2+a^2)^2}$	14.	$\cos(at)+at\sin(at)$	$\frac{s(s^2+3a^2)}{(s^2+a^2)^2}$
15.	$\sin(at+b)$	$\frac{s\sin(b)+a\cos(b)}{s^2+a^2}$	16.	$\cos(at+b)$	$\frac{s\cos(b)-a\sin(b)}{s^2+a^2}$
17.	$\sinh(at)$	$\frac{a}{s^2-a^2}$	18.	$\cosh(at)$	$\frac{s}{s^2-a^2}$
19.	$e^{at}\sin(bt)$	$\frac{b}{(s-a)^2+b^2}$	20.	$e^{at}\cos(bt)$	$\frac{s-a}{(s-a)^2+b^2}$
21.	$e^{at}\sinh(bt)$	$\frac{b}{(s-a)^2-b^2}$	22.	$e^{at}\cosh(bt)$	$\frac{s-a}{(s-a)^2-b^2}$
23.	$t^n e^{at},\ \ n=1,2,3,\ldots$	$\frac{n!}{(s-a)^{n+1}}$	24.	$f(ct)$	$\frac{1}{c}F\left(\frac{s}{c}\right)$
25.	$u_c(t)=u(t-c)$	$\frac{e^{-cs}}{s}$	26.	$\delta(t-c)$	e^{-cs}
	Heaviside Function			Dirac Delta Function	
27.	$u_c(t)f(t-c)$	$e^{-cs}F(s)$	28.	$u_c(t)g(t)$	$e^{-cs}\mathcal{L}\{g(t+c)\}$
29.	$e^{ct}f(t)$	$F(s-c)$	30.	$t^n f(t),\ \ n=1,2,3,\ldots$	$(-1)^n F^{(n)}(s)$
31.	$\frac{1}{t}f(t)$	$\int_s^\infty F(u)\,du$	32.	$\int_0^t f(v)\,dv$	$\frac{F(s)}{s}$
33.	$\int_0^t f(t-\tau)g(\tau)\,d\tau$	$F(s)G(s)$	34.	$f(t+T)=f(t)$	$\frac{\int_0^T e^{-st}f(t)\,dt}{1-e^{-sT}}$
35.	$f'(t)$	$sF(s)-f(0)$	36.	$f''(t)$	$s^2F(s)-sf(0)-f'(0)$
37.	$f^{(n)}(t)$	$s^nF(s)-s^{n-1}f(0)-s^{n-2}f'(0)\cdots-sf^{(n-2)}(0)-f^{(n-1)}(0)$			

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